

THE GENERA OF MENYANTHACEAE IN THE SOUTHEASTERN UNITED STATES¹

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MENYANTHACEAE Dumortier, Anal. Fam. Pl. 20, 25. 1829,
“Menyanthideae.”

Marsh, wetland, or aquatic perennial [or annual] herbs with alternate, simple or 3-foliolate, exstipulate leaves with sheathing petiole bases. Inflorescences various, monopodial or sympodial. Flowers regular (actinomorphic), perfect and often distylous, to imperfect. Calyx of 5 free or united sepals. Corolla sympetalous, 5-lobed, the lobes valvate or induplicate-valvate in bud, often with the margins and sometimes the inner surface fringed or bearded. Stamens 5, epipetalous, alternate with the corolla lobes, the anthers versatile, sagittate at base. Nectaries usually present at base of ovary. Gynoecium syncarpous, 2-carpellate, the calyx and corolla adnate to the lower part; style single, the stigma 2-lobed; ovary 1-locular, with numerous ovules on 2 (or 3) parietal placentae. Fruit a 2–4-valved capsule, or ± fleshy and irregularly dehiscent or indehiscent. Seeds numerous to few, usually smooth (or variously ornamented), with copious endosperm and a cylindrical embryo. (Tribe Menyantheae Griseb.) TYPE GENUS: *Menyanthes* L.

A small family of five genera and about 45 species: *Menyanthes* L., *Fauria* Franchet (*Nephrophyllidium* Gilg), and *Liparophyllum* J. D. Hooker, each with a single species; *Villarsia* Ventenat, with 12 species in Australia and one in South Africa; and *Nymphoides* Séguier, with about 30 species in Africa, Australia, tropical America, eastern North America, and Europe. *Menyanthes tri-*

¹Prepared for the Generic Flora of the Southeastern United States, a project of the Arnold Arboretum currently made possible through the support of the National Science Foundation, under Grant DEB-81-11520 (Carroll E. Wood, Jr., principal investigator). This treatment, the 100th in the series, follows the format established in the first paper (Jour. Arnold Arb. 39: 296–346. 1958) and continued to the present. The area covered by the Generic Flora includes North and South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Arkansas, and Louisiana. The descriptions are based primarily on the plants of this area, with information about extraregional members of a family or genus in brackets []. References that I have not verified are marked with an asterisk.

I am indebted to Dr. Norton Miller for his editorial and bibliographic help, and to Dr. Robert Ornduff, who has kindly read the manuscript and offered several suggestions and additional references. The illustration was prepared by the late Dorothy H. Marsh in 1957, long before Dr. Ornduff showed that *Nymphoides cordata* is dioecious. The living material came from Bateman's Pond in Concord, Massachusetts, where only the staminate plant occurs, and the other materials came from specimens in the Gray Herbarium from Florida (e, f, Godfrey 55096 & Kral), South Carolina (g, Godfrey & Tryon 405), and New York (h, Muenscher 3541).

foliata L. is circumboreal in distribution. *Fauria Crista-galli* (Menzies ex Hooker) Makino is bicentric, with subsp. *Crista-galli*, $2n = 102$, in western North America (coastal Washington and British Columbia, northward to the Gulf of Alaska) and subsp. *japonica* (Franchet) Gillett, $2n = 68$, in eastern Asia (southern Kuril Islands, the Japanese islands of Hokkaido and Honshu, and southern Korea). *Liparophyllum Gunnii* J. D. Hooker is restricted to Tasmania and New Zealand.

Variously recognized as a tribe of the Gentianaceae (Grisebach, Bentham & Hooker), as a subfamily (Gilg, Rendle), or as a family (Cronquist, Hutchinson, Lindsay, Takhtajan, Thorne, Wagenitz), the Menyanthaceae differ from the Gentianaceae in their marsh or aquatic habitat; alternate, petiolate leaves; collateral vascular bundles; valvate or induplicate-valvate aestivation of the corolla lobes; fused lateral corolla traces and \pm bilaterally symmetrical vascular plan in the flowers; tenuinucellar ovules with a single integument and integumentary tapetum; cellular endosperm development; and chemistry (loganin present, gentiopicrin and L-(+)-bornesitol absent). The Menyanthaceae are generally agreed to be related to the Gentianaceae but were placed in the Polemoniales by Cook and in the Solanales by Cronquist.

Nilsson has distinguished two pollen types in the family: the *Menyanthes* type (*Menyanthes*, *Fauria*), with "3-colporate, generally subprolate to prolate, striate to rugulose" grains; and the *Villarsia* type (*Villarsia*, *Nymphoides*, *Liparophyllum*), with "3-colporate, generally oblate to suboblate, parasymplicate, striate, rugulose, spinulose, verrucose or \pm smooth" grains. He found that pollen morphology supports an alliance of Menyanthaceae with Gentianaceae, *Menyanthes* and *Fauria* having pollen "similar to such genera as *Gentiana*, *Crawfurdia*, etc."

Heterostyly and associated self-incompatibility occur in *Fauria*, *Menyanthes*, *Nymphoides*, and *Villarsia*. *Liparophyllum* is monomorphic and self-compatible (Ornduff, 1982). Both homostylous self-compatible and heterostylous self-incompatible species occur in *Villarsia* (Ornduff, 1974), and dioecious species occur in *Nymphoides* (Ornduff, 1966). Gynodioecy has been recorded in *N. cristatum* (Vasudevan Nair). In heterostylous species pollen grains from short-styled flowers are larger than those from long-styled ones.

The family is of little economic consequence. *Menyanthes* has been used rarely in medicine. Several species of *Nymphoides* (especially *N. peltata*) are grown to a limited extent as ornamental, floating-leaved aquatics.

REFERENCES:

- AGABABIAN, V. S., & K. T. TUMANIAN. Palynomorphological study of the family Gentianaceae. IV. (In Russian.) Biol. Zhur. Armenii 30(8): 43–53. 1977. [Includes four genera of Menyanthaceae.] [See also *Ibid.* 33: 466–471. pls. 1–4. 1980.]
- ALSTON, R. E., & B. L. TURNER. Biochemical systematics. 404 pp. Englewood Cliffs, New Jersey. 1963. [Menyanthaceae reported to have loganin, Gentianaceae do not; Menyanthaceae lack gentiopicrin, which Gentianaceae have.]
- ANDREAS, B. K., & T. S. COOPERRIDER. The Gentianaceae and Menyanthaceae of Ohio. Castanea 46: 102–108. 1981. [*Menyanthes* extant in Licking, Summit, and Wayne counties, once distributed from central to northeastern Ohio; *Nymphoides peltata* recorded from Ashtabula.]

- ARBER, A. Water plants. *Frontisp.* + xvi + 436 pp. Cambridge, England. 1920. [*Menyanthes*, 199, 205, 313; *Nymphoides peltatum*, see especially 39–41, 240–243.]
- ASTON, H. I. Aquatic plants of Australia. xvi + 368 pp. Melbourne. 1973. [Menyanthaceae, 105–133; *Nymphoides*, 12 spp., 106–117; *Villarsia*, 12 spp., 118–132; (*Liparophyllum*, 133).]
- BAILEY, L. H., E. Z. BAILEY, & STAFF OF L. H. BAILEY HORTORIUM. Hortus third. xvi + 1290 pp. New York & London. 1976. [Gentianaceae, 503; *Fauria*, 472; *Menyanthes*, 728; *Nymphoides*, 773, 774.]
- BAILLON, H. Gentianacées. Hist. Pl. 10: 113–145. 1889. [Série des Ményanthes, 121–123; Menyantheae, 144, 145.]
- BEAL, E. O. A manual of marsh and aquatic vascular plants of North Carolina with habitat data. N. Carolina Agr. Exper. Sta. Tech. Bull. 247. iv + 298 pp. 1977. [Gentianaceae, 231–235; *Nymphoides*, 234; *Menyanthes*, 235.]
- BENTHAM, G., & J. D. HOOKER. Gentianeae. Gen. Pl. 2: 799–820. 1876. [Menyantheae, 803, 819, 820.]
- BOLKHOVSKIKH, Z., V. GRIF, T. MATVEJEVA, & O. ZAKHARYEVA. Chromosome numbers of flowering plants. A. A. FEDEROV, ed. 926 pp. Acad. Sci. USSR. V. L. Komarov Bot. Inst. Leningrad. 1969. [Menyanthaceae, 432.]
- BREWBAKER, J. L. The distribution and phylogenetic significance of binucleate and trinucleate pollen grains in the angiosperms. Am. Jour. Bot. 54: 1069–1083. 1967. [Includes 1908 genera, approx. half of these studied by the author; Gentianales, 1075.]
- COOK, C. D. K. Menyanthaceae. Pp. 231, 232 in V. H. HEYWOOD, consultant ed., Flowering plants of the world. New York. 1978. [Includes illustrations of *Menyanthes*, *Liparophyllum*, *Nymphoides peltata*; family placed in Polemoniales, but text relates Menyanthaceae to Gentianaceae.]
- CRONQUIST, A. An integrated system of classification of flowering plants. 1262 pp. New York. 1981. [Refers Menyanthaceae to Solanales rather than to Gentianales.]
- DAVIS, G. L. Systematic embryology of the angiosperms. x + 528 pp. New York. 1966. [Gentianaceae, 126, 127; Menyanthaceae, 176.]
- EICHLER, A. W. Blüthendiagramme. Erster Theil. 348 pp. Leipzig. 1875. [Gentianaceae (incl. Menyanthaceae), 245–249; fig. 134C, *Menyanthes*.]
- ERDTMAN, G. Pollen morphology and plant taxonomy. Angiosperms. 539 pp. Stockholm. 1952. (Corrected reprint with addendum [pp. 541–553]. New York. 1971.) [Gentianaceae (incl. Menyanthaceae), 183–185.]
- GANDERS, F. R. The biology of heterostyly. New Zealand Jour. Bot. 17: 607–635. 1979. [Heterostyly in *Fauria*, *Menyanthes*, *Nymphoides*, *Villarsia*.]
- GASTALDO, P. Compendium of the Italian medicinal flora. Fitoterapia 46(2): 57–82. 1975.* [Includes *Menyanthes*.]
- GILG, E. Gentianaceae. Nat. Pflanzenfam. IV. 2: 50–108. 1895. [Menyanthoideae, 105–108.]
- GILLETT, J. M. The gentians [Gentianaceae] of Canada and Greenland. 99 pp. Research Branch, Canada Dept. Agr. Ottawa. 1963. [Menyanthaceae: *Menyanthes*, *Fauria*, *Nymphoides*, 82–90. Keys, nomenclature, descriptions, comments, illustrations, distribution maps.]
- . The systematics of the Asiatic and American populations of *Fauria Crista-galli* (Menyanthaceae). Canad. Jour. Bot. 46: 92–96. 1968.
- GLÜCK, H. Biologische und morphologische Untersuchungen über Wasser- und Sumpfgewächse. IV. Untergetauchte und Schwimmblattflora. 746 pp. Jena. 1924.
- GRISEBACH, A. H. R. Genera et species Gentianearum. viii + 364 pp. Stuttgart & Tübingen. 1838. [Tribus Menyanthideae, 336–348.]
- . Gentianaceae. In: A. DE CANDOLLE, Prodr. 9: 38–141. 1845. [Tribus II. Menyantheae, 136–141.]
- GUÉGUEN, F. Anatomie comparée du tissu conducteur du style et du stigmate des

- Phanérogames (II. Dicotylédones, apétales et gamopétales). Jour. Bot. Morot **16**: 48–65. 1902. [Gentianées, 64, 65; includes *Menyanthes* and *Nymphoides*.]
- GUÉRIN, P. Recherches sur le développement et la structure anatomique du tégument séminal des Gentianacées. Jour. Bot. Morot **18**: 33–52, 83–88. 1904. [Ményanthoïdées, 83–85.]
- . Le développement de l'anthère chez les Gentianacées. Bull. Soc. Bot. France **73**: 5–18. 1926. [*Limnanthemum* (*Nymphoides*), *Menyanthes*, 15–17.]
- GUPPY, H. B. Water-plants and their ways. Their dispersal and its observation. Sci.-Gossip, II. **1**: 145–147. 1894.
- HARA, H. Contributions to the study of variations in the Japanese plants closely related to those of Europe or North America. Part 2. Jour. Fac. Sci. Univ. Tokyo Bot. **6**: 343–391. 1956. [*Menyanthes*, 360; *Nymphoides peltata*, 361.]
- HEGI, G. Gentianaceae. Illus. Fl. Mittel-Europa **5**(3): 1953–2042. pls. 214–217. 1926; 2043–2047. 1927. (Nachdruck der 1. Aufl. 1966.) [*Menyanthes*, 1957–1960, pl. 214, fig. 1; *Nymphoides peltata*, 1961–1964, pl. 214, fig. 2.]
- HOWARD, R. A. Some observations on the nodes of woody plants with special reference to the problem of the split-lateral versus the common gap. Pp. 195–214 in N. K. B. ROBSON, D. F. CUTLER, & M. GREGORY, eds., New research in plant anatomy. New York & London. 1971. (Bot. Jour. Linn. Soc. London **63**(Suppl. 1). 1970.) [Gentianaceae, 204; quotes Sinnot re *Menyanthes*; 3–5 bundles enter leaf from as many gaps.]
- HUTCHINSON, J. The families of flowering plants. Vol. 1. Dicotyledons. xiv + 328 pp. London. 1926. [Gentianaceae, 288, 290.] ed. 2. xv + 510 pp. Oxford. 1959. [Gentianaceae, 450, 451; Menyanthaceae, 451–453; *Menyanthes* illustrated.] ed. 3. xx + 968 pp. Oxford. 1973. [Gentianaceae, 554, 555; Menyanthaceae, 555–557; *Menyanthes* illustrated.]
- . Evolution and phylogeny of flowering plants. xxv + 717 pp. London & New York. 1969. [Gentianales (Gentianaceae, Menyanthaceae), 546–552; Menyanthaceae, 547, 552.]
- INOUE, H., S. UEDA, & Y. NAKAMURA. Biosynthesis of the bitter glycosides of Gentianaceae, gentiopicroside, swertiamarin, and sweroside. (In German.) Tetrahedron Lett. **1967**: 3221–3226. 1967.*
- JENSEN, S. R., B. J. NIELSEN, & R. DAHLGREN. Iridoid compounds, their occurrence and systematic importance in the angiosperms. Bot. Not. **128**: 148–180. 1975. [Gentianales, 165–167; families of Gentianales mainly characterized by occurrence of seco-iridoids (reported in both Gentianaceae and Menyanthaceae).]
- KNOBLAUCH, E. Beiträge zur Kenntniss der Gentianaceae. Bot. Centralbl. **60**: 321–334, 353–363, 385–401. 1894. [Tribe Menyantheae, 398–401; *Menyanthes*, *Villarsia*, *Nymphoides*.]
- KRISHNA, G. G., & V. PURI. Morphology of the flower of some Gentianaceae with special reference to placenta. Bot. Gaz. **124**: 42–57. 1962.
- LAWRENCE, G. H. M. Taxonomy of vascular plants. xiii + 823 pp. New York. 1951. [Gentianaceae, including Menyanthaceae, 670–672; *Nymphoides peltata* illustrated.]
- LEBRETON, P., & M. P. DANGY-CAYE. Biochemical contribution to the taxonomic study of Gentianaceae. Pl. Med. Phytotherap. **7**(2): 87–94. 1973.* [Includes *Menyanthes* and *Nymphoides*.]
- LERSTEN, N. R. A review of septate microsporangia in vascular plants. Iowa State Jour. Sci. **45**: 487–497. 1971. [Includes Gentianaceae.]
- LINDSEY, A. A. Anatomical evidence for the Menyanthaceae. Am. Jour. Bot. **25**: 480–485. 1938. [Concludes that Menyanthaceae “merits full family status.”]
- MAHESWARI DEVI, H. Embryological studies in the Gentianaceae: Gentianoideae and Menyanthoideae. Proc. Indian Acad. Sci. B. **56**: 195–216. 1962.*
- MARTIN, A. C. The comparative internal morphology of seeds. Am. Midl. Nat. **36**: 513–660. 1946. [Gentianaceae, 588, 627; Menyanthaceae, 574, 575.]

- MUENSCHER, W. C. Aquatic plants of the United States. x + 374 pp. Ithaca, New York. 1944. [Menyanthaceae, 301–306; *Menyanthes*, 3 spp.; *Nymphoides* illustrated; seedlings of *N. cordatum* and *N. peltatum* illustrated.]
- MÜHLBERG, H. The complete guide to water plants. 392 pp. (including 109 color + 112 black-and-white photographs). EP Publishing. 1982. [Menyanthaceae, 187–190; *Menyanthes*, color photo 85; *Nymphoides peltata*, color photos 86, 87.]
- NETOLITZKY, F. Anatomie der Angiospermen-Samen. Handb. Pflanzenanat. II. Arche-
gon. 10. vi + 365 pp. 1926. [Gentianaceae, 263–266; Menyanthoideae, 264.]
- NILSSON, S. Menyanthaceae Dum. Taxonomy by R. ORNDUFF. World Pollen and Spore
Flora 2. 19 pp. Stockholm. 1973. [Includes all genera.]
- ORNDUFF, R. Heterostyly in South African flowering plants: a conspectus. (Afrikaans
abstract.) Jour. S. Afr. Bot. 40: 169–187. 1974. [Gentianaceae, 173, 175; Menyan-
thaceae, 179—distyly in *Villarsia capensis*, *Nymphoides Thunbergiana*.]
- PERROT, E. Anatomie comparée des Gentianées aquatiques (Menyanthées Griseb.). Bull.
Soc. Bot. France 44: 340–354. pl. 12. 1897. [*Menyanthes*, *Fauria*, *Villarsia*, *Lim-
nanthemum* (*Nymphoides*), *Liparophyllum*.]
- . Anatomie comparée des Gentianacées. Ann. Sci. Nat. Bot. VIII. 7: 105–292.
pls. 1–9. 1899. (Reprinted as Thèse, Fac. Sci. Paris, 1899.) [Maintains Gentianaceae
with two subfamilies.]
- PROGEL, A. Gentianaceae. In: C. F. P. von MARTIUS, Fl. Brasil. 6(1): 197–248. pls. 54–
66. 1865. [*Limnanthemum*, 243, 244; *L. Humboldtianum*, *L. microphyllum*.]
- RENDLE, A. B. The classification of flowering plants. Vol. 2. Dicotyledons. xx + 640 pp.
Cambridge, England. 1938. [Gentianaceae, including subfams. Gentianoideae and
Menyanthoideae, 463–468.]
- RICKETT, H. W. Wildflowers of the United States. Vol. 1. The northeastern states. 560
pp. New York. 1966. [Gentianaceae, 306–314; *Menyanthes* and *Nymphoides*, 314,
pl. 96.] Vol. 2. The southeastern states. 689 pp. New York. 1966. [Gentianaceae,
389–397; *Nymphoides*, 397, pl. 144.] Vol. 3. Texas. 556 pp. New York. 1969.
[Gentianaceae, 281–284; *Nymphoides aquatica*, 284, pl. 85.]
- RIDLEY, H. N. The dispersal of plants throughout the world. xx + 744 pp. Ashford,
Kent. 1930. [*Menyanthes*, 218, 373, 464, 490, 491, 517, 546; *Nymphoides* (as *Lim-
nanthemum*), 218.]
- RORK, C. L. Cytological studies in the Gentianaceae. Am. Jour. Bot. 36: 387–401. 1949.
- SCHILLING, N. Distribution of L-(+)-bornesitol in the Gentianaceae and Menyanthaceae.
Phytochemistry 15: 824–826. 1976. [In 23 of 32 genera investigated; absent only in
subtribe Exicinae and in Menyanthaceae.]
- SCOGGAN, H. J. Gentianaceae. Fl. Canada 4: 1234–1246. 1978.
- SCULTHORPE, C. D. The biology of aquatic vascular plants. xviii + 610 pp. London.
1967. [Includes numerous references to *Menyanthes* and *Nymphoides*.]
- STOLT, K. A. H. Zur Embryologie der Gentianaceen und Menyanthaceen. Sv. Vet.-
Akad. Handl. II. 61(14): 1–56. 1921.
- TAKHTAJAN, A. L. Outline of the classification of flowering plants (Magnoliophyta). Bot.
Rev. 46: 225–359. 1980. [Gentianales, 292, 293.]
- THORNE, R. F. A phylogenetic classification of the Angiospermae. Evol. Biol. 9: 35–
106. 1976. [Superorder Gentianiflorae, 90–92.]
- TUTIN, T. G. Menyanthaceae. In: T. G. TUTIN et al., eds., Fl. Europaea 3: 67, 68. 1972.
[*Menyanthes trifoliata*, *Nymphoides peltata*.]
- VIJAYARAGHAVAN, M. R., & U. PADMANABAN. Morphology and embryology of *Cen-
taurium ramosissimum* Druce and affinities of the family Gentianaceae. Beitr. Biol.
Pflanzen 46: 15–37. 1969.
- WAGENITZ, G. Gentianales (Contortae, Loganiales, Apocynales). In: H. MELCHIOR, A.
Engler's Syllabus der Pflanzenfamilien. ed. 12. 2: 405–424. 1964. [Menyanthaceae,
410, 411.]

WETTSTEIN, R. *Handbuch der systematischen Botanik.* ed. 3. viii + 1081 pp. Leipzig & Vienna. 1924. [Menyanthaceae, 811, 812.]

WILLIS, J. C. *A dictionary of the flowering plants and ferns.* ed. 7. (Revised by H. K. AIRY SHAW). xxii + 1214 pp. + key to the families of flowering plants (liii pp.). Cambridge, England. 1966. [Menyanthaceae, 714, 715].

KEY TO THE GENERA OF MENYANTHACEAE IN THE
SOUTHEASTERN UNITED STATES

General characters: *Marsh or aquatic herbs with simple or compound alternate leaves; corolla regular, sympetalous, the 5 stamens alternate with the 5 lobes; gynoecium syncarpous, 2-carpellate, adnate at the base to the perianth, the ovary 1-locular with 2 parietal placentae; fruit a dehiscent or indehiscent capsule.*

Leaves 3-foliate, emersed; palustrine herbs with a creeping rhizome; inflorescences racemose, emersed; corolla lobes valvate in bud; petals bearded on the inner surface; fruits borne above water, dehiscent, 2-valved. 1. *Menyanthes*.

Leaves simple, cordate to reniform, floating or submersed; aquatic herbs; inflorescences cymose, the flowers opening singly above water; corolla lobes induplicate-valvate in bud; petals not bearded on the inner surface; fruits ripening under water, indehiscent or opening irregularly. 2. *Nymphoides*.

1. *Menyanthes* Linnaeus, Sp. Pl. 1: 145. 1753; Gen. Pl. ed. 5. 71. 1754.

Glabrous perennial aquatic herbs with creeping sympodial rhizomes bearing adventitious roots and a cluster of leaves at the apex; leaves and flowers emergent from water. Leaves alternate, ternate, petiolate, with large, membranaceous, sheathing bases. Inflorescences racemose on a leafless scape from the terminal bud of the rhizome. Flowers distylous (heterostylous, dimorphic), each subtended by a small bract. Calyx 5-lobed, synsepalous, the lobes partly recurved. Corolla deeply 5-lobed, pink outside, [pink to] white inside, the tube short, adnate to base of ovary, the lobes 3-veined, valvate in bud, the inside of lobes bearded with white fimbriae. Stamens at sinuses of lobes, the anthers basifixed, introrse. Style terminal, the stigma 2-lobed; ovary globular, the placentae parietal. Fruit a 2-valved loculicidal capsule, opening along lateral sutures, with numerous (ca. 20) seeds. Seeds light brown, shining, elliptical, slightly compressed, with abundant endosperm and a cylindrical embryo.
 LECTOTYPE SPECIES: *M. trifoliata* L.; typified by the transfer from *Menyanthes* to *Villarsia* of two of the three Linnaean species (Ventenat, Choix de Plantes, pl. 9. 1803); see also Britton & Brown, Illus. Fl. No. U. S. Canada. ed. 2. 3: 17. 1913. (Name used by Theophrastus, from Greek *menyein*, disclosing, and *anthos*, flower; later applied to this genus with flowers expanding in succession in the raceme.) — BOG BEAN, BUCK BEAN.

The single species, *Menyanthes trifoliata*, $2n = 54$, is circumpolar in distribution in cold bogs, boggy meadows, fens, and shallow waters of pond margins, mainly between lat. 40° N and the Arctic Circle. It occurs in most of Europe but is rare in the Mediterranean region (Tutin), and it is distributed eastward to eastern Central Asia, Siberia, the Himalayas, Tibet, western China and Manchuria, Korea, Sakhalin, and Japan (Hokkaido, Honshu, and northern Kyushu) (Hara). In North America it is found from Greenland, Labrador, and

Newfoundland, west to Alaska, and south to the limit of the Wisconsinan glaciation, with scattered, often disjunct localities in the eastern United States in New Jersey, Delaware, and Pennsylvania, northern Virginia (Madison and Augusta counties), eastern West Virginia (Pocahontas County), northwesternmost North Carolina (Wautauga County), Ohio, Indiana, Illinois, Missouri (Reynolds County, in the southeastern Ozarks), and Nebraska. In the western United States it occurs mostly at higher altitudes south to Colorado, Montana, Wyoming, Nevada, California (in the Sierra Nevada), and southern Oregon.

Fernald segregated the eastern American representatives from the European plants as a weakly defined geographical variety (var. *minor* Raf.) on the basis of corolla size, color, and bearding of the upper surface of the lobes.

The species is distylous (or possibly monomorphic in some localities; see Avebury), but collectors seldom indicate whether both long- and short-styled forms are present in a given population. Long-styled plants of var. *trifoliata* have smaller pollen grains than short-styled ones (see Nilsson, Fossel & Vorwohl), but the situation is inconsistent in var. *minor* (Nilsson).

According to Guppy, seeds of *Menyanthes* float for two months. Ravn noted the buoyant seed coat. Ridley recorded that the seeds have been found in the excreta of reindeer, and in the crops of the European wild duck and the American mallard duck. Hochreutiner, who fed the seeds to three species of fish, found that nearly all germinated after passage (1–3 days) through the digestive tract.

On the basis of morphology, *Menyanthes* is presumably most closely related to *Fauria*, a relationship supported by pollen morphology.

The dried leaves of *Menyanthes* have been used as a substitute for hops in brewing. The very bitter juice has been used as a remedy for bowel trouble and dyspepsia; in large doses the effect is purgative and emetic. It has also been used as a tonic, an astringent, an antirheumatic, and a febrifuge.

REFERENCES:

- Also see family references, especially AGABABIAN & TUMANIAN; ANDREAS & COOPERRIDER; ARBER; BAILEY, BAILEY *et al.*; BAILLON; BEAL; EICHLER; ERDTMAN; GANDERS; GASTALDO; GILLETT; GRISEBACH; GUÉGUEN; GUERIN; GUPPY; HARA; HEGI; HOWARD; HUTCHINSON; KNOBLAUCH; LEBRETON & DANGY-CAYE; LINDSEY; MARTIN; MUENSCHER; NETOLITZKY; NILSSON; PERROT; RENDLE; RICKETT, 1966; RIDLEY; RORK; SCOGGAN; SCULTHORPE; STOLT; and TUTIN.
- AVEBURY, LORD [J. L. LUBBOCK]. Notes on the life history of British flowering plants. xxiii + 452 pp. London. 1905. [*Menyanthes*, 288, 289.]
- CLARKSON, R. B. The vascular flora of the Monongahela National Forest, West Virginia. *Castanea* 21: 1–120. 1966. [Cranberry Glades, Pocahontas Co., locality for *Menyanthes* at its southern limit in West Virginia, 26–69. Also mentions population at Big Meadows Bog in Shenandoah National Park, Virginia.]
- COULT, D. A., & K. B. VALLANCE. Observations on the gaseous exchanges which take place between *Menyanthes trifoliata* L. and its environment. *Jour. Exper. Bot.* 9: 384–402. 1958.*
- DOROFEEV, P. I. The Miocene flora from the environs of the village Yurovskoye on Irtysh. (In Russian.) *Bot. Zhur.* 51: 1480–1489. 1966. [Includes *M. parvula* Nikit.]
- FERNALD, M. L. *Menyanthes trifoliata*, var. *minor*. *Rhodora* 31: 195–198. 1929. [Var. *minor* Michx. ex Raf. the taxon in Atlantic North America.]

- FOSSEL, A., & G. VORWOHL. Honigbienen und Fieberklee (*Menyanthes trifoliata*). Phyton Austria **16**: 49–55. pl. 3. 1974.
- GROEGER, G., & P. SIMCHEN. Incorporation of loganin into gentiopicroside. Zeit. Naturf. **24B**: 356, 357. 1969.* [Swertia spp., *Menyanthes*.]
- HEWITT, D. G. Biological flora of the British Isles. *Menyanthes trifoliata* L. Jour. Ecol. **52**: 723–735. 1964. [Detailed account.]
- HOCHREUTINER, G. Dissémination des graines par les poissons. Bull. Herb. Boiss. **7**: 459–466. 1899. [*Menyanthes*, 461, 462.]
- HOUSE, H. D. Wild flowers of New York. Part 2. ii + pp. 187–362. pls. 144–264. Albany, New York. 1920. (Popular ed. in 1 vol. 362 pp. + 264 pls. 1934.) [*M. trifoliata* (var. *minor*), 220, pl. 169, in both eds.]
- INOUE, H., T. YOSHIDA, S. TOBITA, & M. OKIGAWA. Studies on monoterpene glucosides, part 9. Chemical correlation between asperuloside and loganin. Tetrahedron **1970**: 3905–3915. 1970.* [Includes *Menyanthes*.]
- JENTYS-SZAFEROWA, J. Seeds of *Menyanthes* L. from the Pliocene to the present time. Práce Inst. Geol. Warsz. **10**. 1953.*
- . Importance of Quaternary materials for research on the historical evolution of plants. Veröff. Geobot. Inst. Rubel Zürich **34**: 67–73. 1958.* [*Carpinus*, *Menyanthes*.]
- KEELEY, S. L., JR., & R. W. KOSKOTCH. Alkaloids and other natural products. Pp. 274–283 in C. K. CAIN, ed., Annual reports in medicinal chemistry. 1970. New York. 1971.* [Includes *Menyanthes*.]
- KOKAWA, S. Some tentative methods for the age-estimation by means of morphometry of *Menyanthes* remains. Jour. Inst. Polytech. Osaka City Univ. D. Biol. **9**: 111–118. 1958.*
- . On the discrete distribution of morphometric values of *Menyanthes* seed remains in Japan. *Ibid.* 119–123.*
- . Morphometric reconstruction of the compressed seed remains of *Menyanthes* in Japan. *Ibid.* **11**: 79–89. 1960.*
- . Distribution and phytostratigraphy of *Menyanthes* remains in Japan. Jour. Biol. Osaka City Univ. **12**. 1961.*
- . Age effect on the morphometric values of the fossil *Menyanthes* seeds in Japan represented by Szaferowa's graphic method. *Ibid.* **13**: 87–98. 1962.*
- . New localities of fossil *Menyanthes* in Japan with reconsideration of its morphometric value distribution. *Ibid.* **14**: 97–106. 1963.*
- KORCHAGINA, I. A. Early Quaternary seed floras in the lower course of the Irtish. (In Russian; English summary.) Bot. Zhur. **43**: 1121–1134. pls. 1–4. 1958. [Includes *Menyanthes*.]
- LENDRACK, K. Beitrag zur Kenntniss der Bestandteile von *Menyanthes trifoliata* und *Erythraea Centaurium*. 27 pp. Berlin. 1892.
- LIEBELT, O. Ueber der Bitterstoffe des Bitterklees (*Menyanthes trifoliata*) und der Barbados-Aloe (*Aloe hepatica*). Inaug. Diss. Jena. 40 pp. Halle. 1875.*
- MATHIESSEN, FR. J. Paleobotanical investigations into some cormophytic macrofossils from the Neogene Tertiary lignites of central Jutland, part III, angiosperms. Dansk Vidensk. Selsk. Biol. Skr. **20**(9): 3–59. 1975.* [*M. tertaria*; Miocene.]
- PAMAKSTYTE-JUKNEVICIENE, G. Some data on chemical composition of sweetflag (*Acorus Calamus* L.) and common bogbean (*Menyanthes trifoliata* L.). (In Russian.) Bot. Sada Pribaltiki 445–450. 1971.*
- PATEL, R. C., J. A. INAMDAR, & N. V. RAO. Structure and ontogeny of stomata in some Gentianaceae and Menyanthaceae complex. Feddes Repert. **92**: 535–550. 1981. [Structure and development of stomata in leaves of 8 genera, 12 spp.: includes *Menyanthes*.]
- PONZO, A. Sulla fillotassi: i nomofilli di *Menyanthes trifoliata* L. Nuovo Giorn. Bot. Ital. II. **44**: 201–222. 1937.

- RAVN, F. K. Sur le faculté de flotter chez les graines de nos plantes aquatiques et marécageuses. (In Danish; also in French.) *Bot. Tidsskr.* **19**: 143–188. 1894. [*Menyanthes*, 157, 182.]
- SHELDON, J. L. *Menyanthes trifoliata* in West Virginia. *Rhodora* **12**: 11, 12. 1910.
- SOUÈGES, R. Embryogénie des Gentianacées. Développement de l'embryon chez le *Menyanthes trifoliata* L. *Compt. Rend. Acad. Sci. Paris* **217**: 488–490. 1943.
- SPETA, F. Proteinkörper in Zellkernen: neue Ergebnisse und deren Bedeutung für die Gefäßspflanzensystematik nebst einer Literaturübersicht für die Jahre 1966–1976. (In German; French and English abstracts.) *Candollea* **32**: 133–163. 1977. [Includes *Menyanthes*.]
- STOUSLAND, C. *Menyanthes trifoliata* L. Pharmakognostische Monographie. Diss. 135 pp. Basel. 1930.*
- SYKES, W. R. Checklist of dicotyledons naturalized in New Zealand. 10. Polemoniales and Boraginaceae. *New Zealand Jour. Bot.* **19**: 311–317. 1981. [*Menyanthes*, 313, at Canterbury and Darfield.]
- THUNBERG, K. P. *Dissertatio de usu Menyanthidis trifoliatae*. Upsala. 1797.*
- TRUCHANOWICZOWNA, J. Fossil seeds of the genus *Menyanthes* in Eurasia. (In Polish; English summary.) *Acta Palaeobot.* **5**(1): 25–53. 2 pls., 7 tables. 1964.
- . Seeds of the genus *Menyanthes* from the Polish Miocene. (In Polish; English summary.) *Ibid.* **8**(1): 31–52. 1 pl. 1967.
- VALLANCE, K., & D. A. COULT. Observations on the gaseous exchanges which take place between *Menyanthes trifoliata* L. and its environment. I. *Jour. Exper. Bot.* **2**: 212–222. 1951.*
- WATTS, W. A. The identity of *Menyanthes microsperma* from the Gort Interglacial, Ireland. *New Phytol.* **70**: 435, 436. 1971. [*Nymphoides cordata*.]
- YAMAGATA, O. A palynological study of a *Menyanthes* bed from Nagano Prefecture, Japan. *Ecol. Rev.* **14**: 267, 268. 1957. [Peaty lignite with *Menyanthes* seeds; no *Menyanthes* pollen.]
- YORDANOV, D., S. DENCEV, & N. NIKOLOV. New chorological data of several species of higher plants. *Izv. Bot. Inst. Bulg. Akad. Nauk* **25**: 211–215. 1974.* [Includes *M. trifoliata*.]

2. ***Nymphoides*** J. F. Séguier, Pl. Veron. (Stirp. Agro Veron. Reper.) **3**: 121. 1754.

Perennial rhizomatous herbs with floating, rounded to cordate leaves (superficially resembling miniature leaves of *Nymphaea* or *Nuphar*). Flowers borne in cymose, umbellike clusters (in our indigenous species at the summit of a slender, petiolelike internode with the petiole of the single floating leaf an apparent continuation of the stem), often with clusters of spurlike or “banana-like” tuberous adventitious roots. Plants [homostylous,] heterostylous (distylous), or dioecious (our indigenous species). Flowers emergent, the corollas white or yellow, delicate, 5-lobed, bearing 5 glandular, staminodelike tufts or fringes of trichomes near the base, 1 opposite each lobe; lobes induplicate-valvate in bud. In heterostylous species (e.g., *N. peltata*) flowers with styles either long and with well-developed 2-lobed stigmas and anthers borne below the level of the stigma on short filaments, or short and with smaller stigmas and anthers borne above the stigmatic level on long filaments; anthers dehiscing introrsely; pollen of long-styled flowers smaller than that of short-styled ones. In dioecious species gynoecium of staminate flowers lacking a style, the stigmas undeveloped, the ovules as large as those of carpellate flowers but nonfunc-

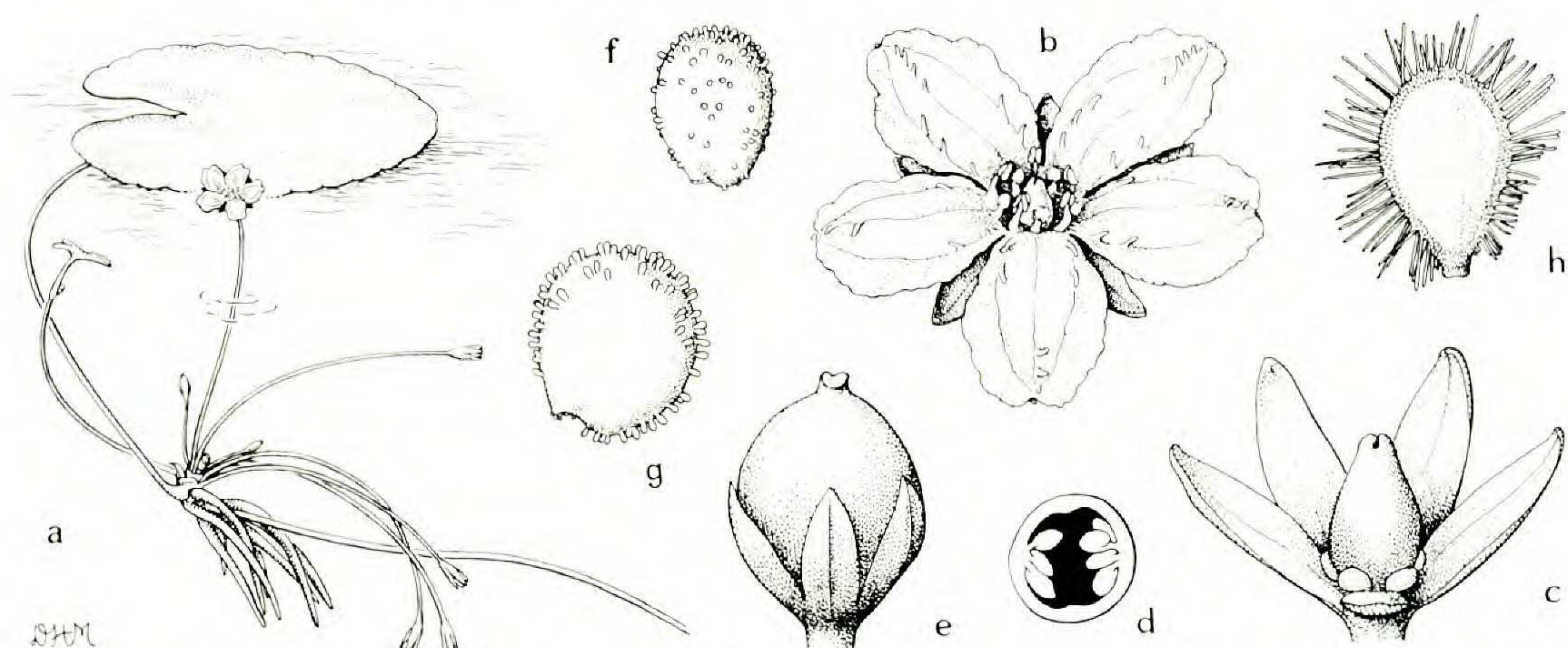


FIGURE 1. *Nymphoides*. a-f, *N. cordata*: a, floating leaf, inflorescence with spurlike adventitious roots, and small branch with unexpanded leaf and inflorescence, $\times \frac{1}{2}$; b, staminate flower, showing staminodiumlike appendages at base of petals and stamens alternating with petals, $\times 3$; c, staminate flower, corolla removed to show sterile gynoecium and 4 of 5 nectar glands at base of ovary, $\times 6$; d, cross section of ovary of staminate flower showing nonfunctional ovules, $\times 8$; e, fruit, $\times 4$; f, seed, $\times 10$. g, *N. aquatica*: seed, $\times 10$. h, *N. peltata*: seed, $\times 4$.

tional; in carpellate flowers the style short, the stigmas well developed, fleshy. Five nectar glands present at base of ovary opposite base of corolla lobes. Fruits maturing under water, small, indehiscent or irregularly dehiscent with small, plump, nearly smooth to papillate seeds, or (in *N. peltata*) the capsules larger, resembling those of *Frasera*, the seeds larger, flat, their margins coarsely ciliate. (*Limnanthemum* S. G. Gmelin.) TYPE SPECIES: *Nymphoides aquis innatans* Tournefort = *N. peltata* (S. G. Gmelin) Kuntze. (Name from Greek, *nymphaia*, and *eidos*, resemblance, from the similarity of the leaves of *N. peltata* to those of the water lily, *Nymphaea*.) — FLOATING-HEART.

A genus of 30–35 species of floating-leaved aquatics, primarily of the tropics, best represented in the Old World (13 species in Africa and Madagascar, 12 species in Australia), with about five species in tropical America and two indigenous to eastern North America. *Nymphoides peltata*, the single Eurasian species, is often cultivated as an ornamental plant and is sporadically naturalized in the United States.

Nymphoides cordata (Ell.) Fern. (*N. lacunosa* sensu Fernald), $2n = 36$, is distributed in quiet “soft” (noncalcareous) waters from Louisiana and western Florida, northward on the Coastal Plain to New England, Nova Scotia, and Newfoundland, southwestern Quebec, and Ontario. It has thin, cordate-ovate floating leaves that are nearly smooth beneath and not densely dark pitted, capsules to 1.5 times the length of the calyx, and small seeds with a smooth to papillate surface. *Nymphoides aquatica* (J. F. Gmelin) Kuntze, banana floating-heart, $2n = 36$, a larger, coarser plant with ovate to reniform leaves with the lower surface usually thickened and densely dark pitted, the petiole and stem densely covered with dark glands, a capsule much larger than the calyx, and larger seeds with a tuberculate or papillate surface, is found on the Coastal

Plain from southern Florida west to eastern Texas, and north to Delaware and southern New Jersey. The corollas of *N. aquatica* are almost twice as large as those of *N. cordata*. However, corollas press so poorly (waxed paper or facial- or toilet-tissue should be used) that they are seldom adequately preserved in herbarium specimens of either these or other members of the genus.

Nymphoides peltata (*Limnanthemum peltatum* S. G. Gmelin, *L. Nymphoides* (L.) Hoffmans. & Link), yellow floating-heart, $2n = 54$, is indigenous to most of Europe north to Sweden and north-central Russia and is distributed eastward through the Caucasus to Iran, India, Taiwan, Mongolia, Manchuria, southern Siberia, Korea, and Japan. It is sporadically naturalized in the United States in New England, New York, New Jersey, Pennsylvania, Maryland, Ohio, Indiana, Illinois, Missouri, Arkansas, Mississippi, Louisiana, Oklahoma, Texas, Arizona, and Washington (see Stuckey). It is the best-studied species of the genus (see references). Sometimes forming dense stands in quiet waters, it overwinters by short-shoots that form new leaves and long-shoots in the spring. The flowering stems develop from a leaf axil of a long-shoot, and the flowers are produced sympodially in cymose, umbellike inflorescences. Each golden-yellow flower (ca. 3.5 cm across) lasts a single day, as in other species. The corolla absorbs ultraviolet light centrally and reflects it peripherally (Van der Velde & Van der Heijden), as do the yellow flowers of the Australian *N. geminata* (R. Br.) Kuntze (see Ornduff & Mosquin). Distyly is coupled with a weak self-incompatibility system. Van der Velde & Van der Heijden recorded 43 species of insects (mostly Apidae, Syrphidae, and Ephydriidae) as visitors to the flowers in the Netherlands. Megagametophyte development is of the Polygonum type. The capsules mature under water one to two months after flowering, then burst open at the base. The flesh becomes soft and decays. The seeds float and are dispersed over the water surface by wind; they also adhere to water birds.

In both of our white-flowered indigenous species, the long, slender first internode of the inflorescence (see Goebel) is often misinterpreted as the long petiole of a floating leaf. Actually, each elongated stem bears a single floating leaf and is terminated by a flower; the cymose inflorescence develops sympodially as in *Nymphoides peltata* and is supported near the surface of the water by the floating leaf-blade (see FIGURE 1). In both species, fleshy spurlike (*N. cordata*) or somewhat banana-shaped (*N. aquatica*) adventitious roots are produced on either side of the inflorescence. These clusters function as overwintering vegetative reproductive structures. Both species are dioecious (Ornduff, 1966); collectors should note the occurrence of staminate and carpellate plants. The ultraviolet reflectance patterns have not been studied, but in the similarly white-flowered *N. indica* (L.) Kuntze the corolla absorbs ultraviolet light uniformly (Ornduff & Mosquin).

The genus includes diploids, tetraploids, and hexaploids ($2n = 18, 36, 54$). The American species studied thus far are tetraploids, and Ornduff (1969) found that the white-flowered tropical American tetraploids generally known as *Nymphoides Humboldiana* (HBK.) Kuntze are conspecific with the Old World white-flowered diploid *N. indica*. Both homostylous self-compatibility and distylous self-incompatibility, as well as dioecism, occur in the genus. Ornduff

(1970) concluded that "dioecism has evolved at least two and perhaps three times in *Nymphoides*" and that it is "evident that tetraploidy has arisen independently in the genus more than once."

Nymphoides is closely related to *Villarsia* Vent., which has about 12 species in Australia and one in South Africa. In comparing the Australian members of the two genera, Aston (1969, 1973) pointed out that in *Nymphoides* the plants are true aquatics, the flowers are in nonpaniculate inflorescences, the pedicels bend downward after flowering, and the fruits ripen under water and are indehiscent or break up irregularly. In *Villarsia* the plants are mostly wetland herbs with erect paniculate (rarely condensed and capitate) inflorescences, the capsules are not carried under water for ripening, and the fruits are usually valvate capsules.

Nymphoides peltata, *N. aquatica*, and *N. indica* (including *N. Humboldtiana*) are cultivated in the United States to limited degrees for their attractive flowers and floating leaves. The somewhat bananlike adventitious roots from the inflorescences of *N. aquatica* are sold as an aquarium oddity, underwater banana plant.

REFERENCES:

- Also see family references, especially AGABABIAN & TUMANIAN; ANDREAS & COOPERRIDER; ARBER; ASTON; BAILEY, BAILEY *et al.*; COOK; GANDERS; GILLETT; GRISEBACH; GUÉGUEN; GUÉRIN; HARA; HEGLI; KNOBLAUCH; LAWRENCE; LEBRETON & DANGY-CAYE; MUENSCHER; NETOLITZKY; NILSSON; ORNDUFF; PERROT; PROGEL; RICKETT; RORK; SCULTHORPE; STOLT; and TUTIN.
- D'ALMEIDA, J. F. R. On the shoot morphology of *Limnanthemum*. *Jour. Indian Bot. Soc.* **7**: 1–11. 1928. [*N. cristata*, *N. indica*.]
- ANONYMOUS. Banana plant, without bananas. *Aquarium* **7**: 173. 1939.*
- ASTON, H. I. The genus *Villarsia* (Menyanthaceae) in Australia. *Muelleria* **2**: 3–63. 1969.
- BARRETT, S. C. H. Dimorphic incompatibility and gender in *Nymphoides indica* (Menyanthaceae). *Canad. Jour. Bot.* **58**: 1938–1942. 1980. [Distylous; lower Amazon, Brazil; strong self- and intramorph-incompatibility system demonstrated among 20 individuals tested.]
- BOYNTON, K. R. *Nymphoides Humboldtianum*. *Addisonia* **11**: 25, 26. pl. 365. 1926. [Illustrates plant from Puerto Rico.]
- CLARK, O. M. Spread of *Nymphoides peltatum* in Lake Messina. *Proc. Oklahoma Acad. Sci.* **18**: 21, 22. 1938. [In newly created lake west of Bristow.]
- CONARD, H. S. The banana floatingheart (*Nymphoides aquaticum*). *Proc. Iowa Acad. Sci.* **44**: 61–64. 1938. [Comparison of hibernating bodies of *N. aquatica* with those of *Nymphaea mexicana*, important as a duck food.]
- CORRELL, D. S., & H. B. CORRELL. Aquatic and wetland plants of southwestern United States. *Frontisp. + xvi + 1777 pp.* Environmental Protection Agency, Washington, D. C. 1972. (Reissued in 2 vols. by Stanford Univ. Press. 1975.) [Gentianaceae, 1312–1332; *N. aquatica* (illustrated), *N. peltata*, 1331, 1332.]
- COUNTRYMAN, W. D. History, spread and present distribution of some immigrant aquatic weeds in New England. *Hyacinth Control Jour.* **8**(2): 50–52. 1970.* [Includes *N. peltata*.]
- CRÉTÉ, P. Ményanthacées. Développement de l'embryon chez le *Limnanthemum Nymphoides* Hoffg. et Link. *Compt. Rend. Acad. Sci. Nat. Paris* **242**: 3110–3113. 1956.*
- DALE, H. M., & G. E. MILLER. Changes in the aquatic macrophyte flora of Whitewater

- Lake near Sudbury, Ontario, Canada from 1947 to 1977. *Canad. Field Nat.* **92**: 264–270. 1978. [*N. cordata*.]
- DEVOL, C. E. Unexpected new finds on Taiwan. *Taiwania* **10**: 151–154. 1964. [*N. coreana*.]
- DRESS, W. J. The identity of the aquatic “banana plant.” *Baileya* **2**: 19–22. 1954. [“Underwater banana plant” = overwintering adventitious tuberous roots produced at base of inflorescences of *N. aquatica*.]
- ELIAS, T. S. Menyanthaceae. In: R. E. WOODSON, JR., et al., eds., *Fl. Panama. Ann. Missouri Bot. Gard.* **56**: 29–32. 1969. [*N. Humboldtiana*.]
- FAUTH, A. Beiträge zur Anatomie und Biologie der Früchte und Samen einiger einheimischer Wasser- und Sumpfpflanzen. *Beih. Bot. Centralbl.* **14**: 327–373. 1903. [Includes fruit and seeds of *Nymphoides peltata* and *Menyanthes*.]
- FENSMON, D. S., & D. C. SPANNER. Electro-osmotic and biopotential measurements on phloem strands of *Nymphoides peltatum*. *Pl. Arch. Wiss. Bot.* **88**: 321–331. 1969.*
- GMELIN, S. G. *Lychnanthes volubilis* et *Limnanthemum peltatum*. *Nov. Comm. Acad. Sci. Imp. Petropol.* **14**(1, 1769): 525–530. *pl. 17*. 1770.*
- GODFREY, R. K., & J. W. WOOTEN. Aquatic and wetland plants of southeastern United States. *Dicotyledons*. x + 933 pp. Athens, Georgia. 1981. [Menyanthaceae: *Nymphoides*, 537–540; *N. peltata*, *N. cordata*, *N. aquatica*.]
- GOEBEL, K. Morphologische und biologische Studien. VI. *Limnanthemum*. *Ann. Jard. Bot. Buitenzorg* **9**: 120–126. *pl. 16*. 1891. [Includes morphology of inflorescence; *N. aurantiaca*, *N. cristata*, *N. Humboldtiana*, *N. indica*, *N. peltata*.]
- HATSCHBACH, G., & N. IMAGUIRE. Meniantaceas do Estado do Paraná, Brasil. *Bol. Mus. Bot. Munic. Curitiba* **9**: 1–5. 1973. [*N. indica*.]
- HAZARNAVIS, L. Microsporogenesis in *Limnanthemum indicum* Thw. *Jour. Biol. Sci.* **2**: 118, 119. 1959.*
- HENSIUS, H. W. Eenige waarnemingen en beschouwingen over de bestuiving van bloemen der Nederlandsche flora door insecten. *Bot. Jaarb.* **4**: 54–144. 1892. [Heterostyly and pollen dimorphism in *N. peltata*.]
- HOUSE, H. D. A new plant joins the Hudson River flora. *Torreya* **37**: 80–82. 1937. [*N. peltata*, as *N. nympheoides*.]
- JONES, W. N. Observations on the response of leaves of *Limnanthemum* and *Tropaeolum* to light and gravity. *Ann. Bot. II.* **2**: 819–825. 1938. [*N. peltata*.]
- KAUL, R. B. Anatomical observations on floating leaves. *Aquatic Bot.* **2**: 215–234. 1976. [24 genera; *Nymphoides*, 226, 227.]
- KEDDY, P. A. Vegetation with Atlantic coastal plain affinities in Axe Lake, near Georgian Bay, Ontario. *Canad. Field Nat.* **95**: 241–248. 1981. [Includes *N. cordata*.]
- MAJUMDAR, G. P. A preliminary note on polystely in *Limnanthemum cristatum* and *Ottelia alismoides*. *Curr. Sci. Bangalore* **6**: 383–385. 1938.*
- MEHTA, A. S. A study of the primary phloem of the petiole of *Nymphoides peltatum* (Gmel.) O. Kunze. *Jour. Indian Bot. Soc.* **43**: 257–261. *pls. 1, 2*. 1964.
- MOOKERJEA, A. Cytology of *Limnanthemum cristatum* Griseb. *Curr. Sci. Bangalore* **20**: 328, 329. 1951.* [2n = 18.]
- ORNDUFF, R. The origin of dioecism from heterostyly in *Nymphoides* (Menyanthaceae). *Evolution* **20**: 309–314. 1966.
- . Neotropical *Nymphoides*: the case for taxonomic provincialism. (Abstr.) *Am. Jour. Bot.* **55**: 736, 737. 1968.
- . Neotropical *Nymphoides* (Menyanthaceae): Meso-American and West Indian species. *Brittonia* **21**: 346–352. 1969. [1970.]
- . Cytogeography of *Nymphoides* (Menyanthaceae). *Taxon* **19**: 715–719. 1970.
- . Cytotaxonomic observations on *Villarsia* (Menyanthaceae). *Austral. Jour. Bot.* **22**: 513–516. 1974.
- . Heterostyly and incompatibility in *Villarsia capitata* (Menyanthaceae). *Taxon* **31**: 495–497. 1982.

- & T. MOSQUIN. Variation in the spectral qualities of flowers in the *Nymphoides indica* complex (Menyanthaceae) and its possible adaptive significance. Canad. Jour. Bot. **48**: 603–605. pl. I. 1970.
- PINKAVA, D. J., E. LEHTO, & D. KEIL. Plants new to Arizona flora, part 2. Jour. Ariz. Acad. Sci. **5**: 226. 1969.* [*N. peltata*, *Catalpa bignonioides*.]
- ponce de LEÓN Y AYMÉ, A. Joyas de la flora cubana. Una pequeña ninfa (*Nymphoides Grayanum* (Griseb.) Arthur). Revista Soc. Cuba. Bot. **15**: 77. 1958.
- RAJ, T. R. N., & K. M. PONNAPPA. Some interesting fungi occurring on aquatic weeds and *Striga* species in India. Jour. Indian Bot. Soc. **49**: 64–72. 1970. [*Cercospora nymphaeacea* on *N. indicum*, 64.]
- RAO, C. G. P. Anatomical studies on fungal galls. I. Preliminary observations on *Phy-soderma* on *Limnanthemum indicum* Thw. Phytomorphology **12**: 201–204. 1962.
- RAYNAL, A. Répartition géographique des *Nymphoides* (Menyanthaceae) africains et malgaches. (English summary.) Mitt. Bot. Staatssam. München **10**: 122–134. 1971. [Twelve spp., one described as new.]
- . Le genre *Nymphoides* (Menyanthaceae) en Afrique et à Madagascar. 1^{re} partie: morphologie. (English summary.) Adansonia II. **14**: 227–270. 1974.
- . *Ibid.* 2^e partie: taxonomie. (English summary.) *Ibid.* 405–458. [13 spp.]
- RAYNAL, J., & A. RAYNAL. Un exemple d'application du traitement électronique de l'information à la construction des clefs dichotomiques. Adansonia II. **14**: 459–467. 1974.
- REDDY, N. P., & B. BAHADUR. Heterostyly in *Nymphoides indica*. Jour. Indian Bot. Soc. **55**: 133–140. 1976.*
- ROYEN, P. VAN. Sertum Papuanum 10. Gentianaceae. Nova Guinea Bot. **17**: 369–416. pl. 37. 1964. [*N. indica*, *N. parvifolia*, *N. hydrocharoides*, 410–414.]
- SCHILLING, A. J. Anatomisch-biologische Untersuchungen über die Schleimbildung der Wasserpflanzen. Flora **78**: 280–360. 1894.
- SHIGENOBU, Y., & R. TANAKA. Karyomorphological studies in three species of *Nymphoides* in Japan. Jour. Jap. Bot. **55**: 20–24. 1980. [*N. coreana*, *N. indica*, *N. peltata*.]
- SINGH, S. P., & R. SAHA. Effect of certain abiotic factors on the development of root tubers of *Nymphoides indica* in a natural lake. Geobios **1**: 181, 182. 1974.*
- SMITH, L. B. A new *Nymphoides* from Colombia. Jour. Washington Acad. Sci. **42**: 160, 161. 1952. [*N. flaccida*.]
- SPANNER, D. C., & R. L. JONES. The sieve tube wall and its relation to translocation. Pl. Arch. Wiss. Bot. **92**: 64–72. 1970.* [*Phaseolus vulgaris* and *N. peltata*.]
- & J. N. PREBBLE. The movement of tracers along the petiole of *Nymphoides peltatum*. I. A preliminary study with ¹³⁷Cs. Jour. Exper. Bot. **13**: 294–306. 1962.*
- SRINIVASAN, A. Cytomorphological features of *Limnanthemum cristatum* Griseb. and *Enicostemma littorale* Blume. Proc. Indian Acad. Sci. B. **14**: 529–542. 1941.*
- SRIVASTAVA, M. G. Chromosome number in genus *Limnanthemum*. Sci. Cult. **21**: 215. 1955.*
- STOVER, E. L. Life history of *Nymphoides peltatum*. Bot. Gaz. **93**: 474–483. 1932. [Embryological study.]
- STUCKEY, R. L. The introduction and distribution of *Nymphoides peltatum* (Menyanthaceae) in North America. Bartonia **42**: 14–23. 1974. [Includes map.]
- VASUDEVAN, R. A new species of *Nymphoides* (Menyanthaceae) from South India. Kew Bull. **22**: 101–106. 1968. [*N. macrosperma*; dioecious.]
- VASUDEVAN NAIR, R. Heterostyly and breeding system of *Nymphoides cristatum* (Roxb.) O. Kuntze. Jour. Bombay Nat. Hist. Soc. **72**: 677–682. 1975.
- VELDE, G. VAN DER. *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae) as a food plant for *Cataclysta lemnata* (L.) (Lepidoptera, Pyralidae). Aquatic Bot. **7**: 301–304. 1979.
- , T. G. GIJSEN, & L. VAN DER HEIJDEN. Structure, biomass and seasonal changes

- in biomass of *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae), a preliminary study. *Aquatic Bot.* **7**: 279–300. 1979.
- & L. A. VAN DER HEIJDEN. The floral biology and seed production of *Nymphoides peltata* (Gmel.) O. Kuntze (Menyanthaceae). *Aquatic Bot.* **10**: 261–293. 1981.
- WAGNER, R. Die Morphologie des *Limnanthemum Nymphaeoides* (L.) Lk. Inaug. Diss. Fac. Kaiser-Wilhelms-Universität, Strassburg. 19 pp. 1895. (*Bot. Zeit.* **53**(1): 189–205. *pl. 8*. 1895.) [*N. peltata*, development, branching, etc.]
- WANG, D. T. Karyokinetic study of *Limnanthemum Nymphoides* Hoffmigg. et Link. *Bull. Fan Mem. Inst. Biol. Bot.* **10**: 113–115. *pl. 6*. 1940.
- WARD, D. B. The genus *Anonymos* and its nomenclatural survivors. *Rhodora* **64**: 87–92. 1962. [*N. aquatica* (J. F. Gmelin) Kuntze, 89, 90.]
- WATTS, W. A. The full-glacial vegetation of northwestern Georgia. *Ecology* **51**: 17–33. 1970. [Macrofossils include seeds determined to be *N. cordata*.]
- . The identity of *Menyanthes microsperma* n. sp. foss. from the Gort Interglacial, Ireland. *New Phytol.* **70**: 435, 436. *pl. 1*. 1971. [Seed remains identified as a species of *Nymphoides*, probably *N. cordata*.]
- WICKS, J. C. Some morphological aids in distinguishing *Nuphar microphyllum* from similar aquatics. *Rhodora* **75**: 65–74. 1973. [*N. cordata*.]
- WILBUR, R. L. The identity of Walter's species of *Anonymos*. *Jour. Elisha Mitchell Sci. Soc.* **78**: 125–132. 1962. [*N. aquatica* (J. F. Gmelin) Kuntze, 128.]
- WIT, H. C. D. DE. Aquarium plants. *Color frontisp.* + 255 pp. + 29 photographs. London. 1964. [*Nymphoides*, 174–178; *N. aquatica*, *N. Humboldtiana*, *N. indica*, *N. peltata*.]

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